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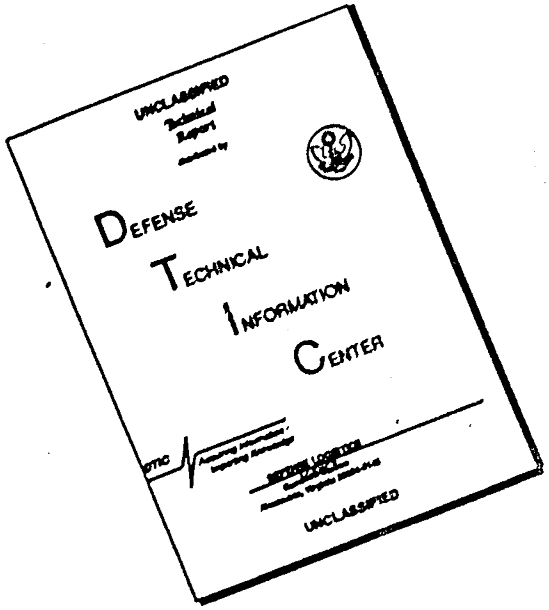

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AID Report 61- 38

21 Mar 1961

ITEM OF INTEREST

Prepared by

Science and Technology Section
Air Information Division

SUBJECT: Control of Nuclear Aircraft Engines

SOURCE: Voronkov, V. S. Nuclear reactor as an object of control. IN: Shevyakov, A. A. (ed.). Avtomaticheskoye regulirovaniye aviadvigateley; sbornik statey, vypusk 2 (Automatic control of aircraft engines; collection of articles, no. 2). Moskva, Oborongiz, 1960, 66-106.

This article is a comprehensive theoretical analysis of nuclear-reactor properties in relation to the basic principles of automatic control of nuclear aircraft engines. Special attention is given to analysis of reactor dynamics and the effect of reactor dynamics on control-system design. The author notes that the control of nuclear aircraft engines involves the question of reactor dynamics in addition to the dynamics of gas-dynamic and mechanical processes associated with a chemically powered jet engine. Reactor dynamics is involved because a variation of nuclear-engine performance is connected with changes of reactor operating regimes.

The discussion includes the concept of the reactor period, the derivation of reactor equations, linearization of reactor equations, transfer function and frequency characteristics of a reactor, temperature coefficient of reactivity and its effect on reactor properties, and control rods.

The analysis resulted in the following conclusions.
1) The nuclear reactor with respect to neutron power output is described by a nonlinear differential equation of the seventh order.
2) At small deviations from the reactor-equilibrium state, reactor equations can be linearized by one of two proposed methods.
3) With respect to disturbances based on the excess multiplication constant (Δk) the reactor is considered as being nonstatic. Positive disturbances result in a continuous unlimited increase in power, while negative disturbances result in a power reduction to zero. Steady-state conditions of a reactor can only be achieved at $\Delta k = 0$.

4) A negative temperature coefficient of reactivity results in a considerable change of reactor properties; the reactor acquires a property of thermal self-regulation. 5) Frequency characteristics of reactors at low frequencies (to approximately 1 1/sec) are determined by delayed neutrons; at high frequencies they are determined by prompt neutrons. 6) The absorptive power of control rods varies nonlinearly with the depth of rod immersion into the reactor [redacted] CORE.

Although the article under discussion represents no new approach to the problem of automatic control of nuclear-powered aircraft engines, it does reveal to a certain extent the scope of Soviet efforts to develop such systems. Direct reference to the subject is rarely found in Soviet open literature.